4.5 GEOLOGY AND SOILS

This section discusses the geology and soils of the project site and the potential risks associated with known geological hazards. This section also assesses potential impacts from seismic and geologic hazards that may occur as a result of the project. Information in this section is drawn in part from the Foundation Report prepared for Fair Oaks Overhead Bridge (bridge) by Parikh Consultants, Inc., included as **Appendix J**

4.5.1 EXISTING CONDITIONS

Seismic and Geological Conditions

Geologic Units

Sunnyvale is located in the Santa Clara Valley, with the San Francisco Bay to the north, the Diablo mountain range to the east, and the Santa Cruz Mountains to the southwest. The project site is underlain by Quaternary[1] sediments, including:

- Holocene[2] alluvial fan[3] and fluvial deposits[4] – medium dense to dense, gravely sand or sandy gravel, that generally grades upward, to sandy or silty clay.
- Pleistocene[5] alluvial fans and fluvial deposits – dense gravely and clayey sand or clayey gravel that fines upward to sandy clay, variously sorted.
- Holocene floodplain deposits – dense sandy to silty clay.
- Holocene basin deposits – very fine silty clay to clay deposits occupying flat-floored basins at the distal edge of alluvial fans.

A geologic map covering the project site is presented in **Appendix J**, which shows that the site is mostly underlain by Holocene alluvial fan and fluvial deposit.

---

[1] The geological period from the end of the Tertiary to the present or Holocene period.

[2] The current geological epoch that began at the end of the Pleistocene and is part of the Quaternary period.

[3] A fan-shaped alluvial deposit formed by a stream where its velocity is abruptly decreased, as at the mouth of a ravine or at the foot of a mountain.

[4] Materials that have been transported and deposited by streams and rivers.

[5] The first epoch of the Quaternary period, beginning about two million years ago and ending 10,000 years ago,

Soils

Soil is generally defined as the unconsolidated mixture of mineral grains and organic material that mantles the land surface. Soils can develop on unconsolidated sediments and weathered bedrock. According to the Foundation Report, subsurface soil conditions at the project site predominately consisted of medium stiff to very stiff lean clay and sandy lean clay interbedded with medium dense to very dense sand, silty and clayey sand, and clayey gravel in the top approximate 50 to 70 feet.

According to the National Resources Conservation Service, Web Soil Survey, two types of soils are mapped as underlying the project site: 1) Urban land alluvial fans and 2) Urban land-Elpaloalto complex. Urban land soils are comprised of miscellaneous urban fill soils from disturbed and transported materials. The Elpaloaloto soils are well drained, derived from alluvium of metamorphic and sedimentary rock or metavolcanics, and have a clay loam texture.[6]

Seismicity

The project site is located outside any designated State of California Earthquake Fault Zone but is within a seismically active part of northern California (see **Figure 4.5-1**). The project site is not crossed by any mapped traces of active faults. **Table 4.5-1** lists the major historically active faults within 10 miles (mi) of the project site.

Table 4.5-1 Active Faults in the Vicinity of the Project

Fault	Approximate Nearest Distance to Project Site (mi)	Maximum Magnitude	Fault Type
Cascade Fault	2.77	6.7	R
Monte Vista-Shannon Fault	4.61	6.4	R
Silver Creek Fault	5.08	6.9	R
San Andreas Fault	8.61	8.0	SS

Note: Maximum magnitude represents the largest earthquake that a fault is capable of generating.
R = Reverse Fault
SS = Strike-slip fault
Source: Parikh, 2013.

[6] H.T. Harvey & Associates, Natural Environment Study (NES), 2013.

The US Geological Survey estimates that there is a 62 percent probability that by 2032 a 6.7 or greater magnitude earthquake will occur in the San Francisco Bay Area Region, and there is a 21 percent probability of magnitude 6.7 or greater earthquake before 2036 on the San Andreas Fault.[7]

Seismic Hazards

Surface Rupture

Surface rupture occurs when the ground surface is broken due to a fault movement during an earthquake. The location of a surface rupture generally can be assumed to be along a major active fault trace. As previously discussed, the project site is not crossed by an active fault or in a designated fault zone. The project site borders an Alquist-Priolo Earthquake Special Studies Zone in the Cupertino Quadrangle, which is crossed by the San Andreas Fault in the southwest corner of the quadrangle.[8] The potential for fault rupture at the project site is considered low.

Ground Shaking

Ground shaking is a general term that refers to all aspects of motion on the earth's surface resulting from an earthquake, and is typically the major cause of damage in seismic events. The extent of ground shaking is controlled by the magnitude and intensity of the earthquake, distance from the epicenter, and local geologic conditions.

Magnitude is a measure of the energy released by an earthquake which is assessed by a seismograph.

Intensity is a subjective measure of the perceptible effects of seismic energy at a given point and varies with distance from the epicenter and local geologic conditions. The Modified Mercalli Intensity Scale (MMI) is the most commonly used scale for measurement of the subjective effects of earthquake intensity (**Table 4.5-2**). Intensity can also be quantitatively measured using accelerometers (strong motion seismographs) that record ground acceleration at a specific location, a measure of force applied to a structure under seismic shaking. Acceleration is measured as a fraction or percentage of the acceleration under gravity (g).

[7] United States Geographic Service (USGS), 2008.

[8] Department of Conservation, Alquist-Priolo Earthquake Fault Zone maps. Available at: http://www.quake.ca.gov/gmaps/WH/regulatorymaps.htm. Accessed 10/22/2013.

As illustrated in **Table 4.5-1**, the faults identified within the vicinity of the project site are capable of generating earthquakes of magnitude 6.4-8.0. Earthquakes of this magnitude are capable of generating strong (VII) to very strong (VIII) seismic shaking on the project site. [9]

Table 4.5-2 Modified Mercalli Intensity (MMI) Scale

MMI Scale	Description
I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

[9] United States Geographic Service (USGS), Magnitude/Intensity Comparison. Available at: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php. Accessed 10/22/2013.

MMI Scale	Description
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted.

Source: California Geological Survey, 2002.

Liquefaction

Liquefaction is a phenomenon in which saturated non-cohesive soils are subject to temporary but essentially total loss of shear strength under the reversing, cyclic shear stresses associated with earthquake shaking. Soils which are susceptible to liquefaction are generally low-plastic silts and submerged cohesionless sands of low density. Clay is typically not susceptible to liquefaction.

Soil conditions at the project site generally consist of medium stiff to very stiff clayey materials interbedded with medium dense to very dense sandy soils, and are not considered to pose a significant liquefaction risk. Isolated pockets of potentially liquefiable sandy soils were found at the project site but do not present significant risk to the soil behaviors at the site given that they are thin and surrounded by relatively thick non-liquefiable soils. Overall liquefaction potential at the project site is considered low.

Geologic Hazards

Soil Erosion

Soil erosion is a natural process that can be caused by wind or water. Eroded soils can be entrained in storm water runoff and be discharged to surface waters, thereby affecting the water quality of receiving waters. Stormwater runoff quality both during and after construction is regulated by the National Pollutant Discharge Elimination System (NPDES) program, which is established through the Federal Clean Water Act. The NPDES program objective is to control and reduce pollutant discharge to surface water bodies. In California, the NPDES program is administered by the State Water Resources Control Board (SWRCB), with local oversight provided by the Regional Water Quality Control Boards (RWQCB).

Expansive Soils

Expansive soils can expand and contract when undergoing alternating cycles of wetting (swelling) and drying (shrinking). During these cycles, the volume of the soil changes markedly. As a consequence of such volume changes, structural damage to buildings and infrastructure may occur if the potentially expansive soils were not considered in project design and during construction. According to the Web Soil Survey of project site, the soil on the project site is predominately urban land underlain by alluvial fans.

Two soil borings were taken in 2012 to provide more specific information about the soil at the project site. The borings revealed that the site contains approximately 50-70 feet of alluvial deposits consisting of clay and silty clay interbedded with sand and gravel. Generally the clayey soils appeared to be medium stiff to very stiff, and the sandy materials medium dense to very dense. Clay and associated materials can result in weak, compressible, or expansive soils. The general area has expansive clays that have moderate to high expansive potential (Parikh, 2014).

Settlement and Differential Settlement

Differential settlement or subsidence could occur if buildings or other improvements were built on low-strength foundation materials (including imported fill) or if improvements straddle the boundary between different types of subsurface materials (e.g., a boundary between native material and fill). Although differential settlement generally occurs slowly enough that its effects are not dangerous to inhabitants, it can cause significant building damage over time. Settlement is considered to have completed given that the bridge was built over 40 years ago (Parikh, 2014).

4.5.2 REGULATORY SETTING

California Building Standards Code

The City of Sunnyvale has adopted the 2010 California Building Codes (CBC) and requires all development within the County to comply with the most current CBC standards. Title 24 of the California Code of Regulations, also known as the California Building Standards Code, sets minimum requirements for building design and construction. The 2010 version of the California Building Standards Code became effective as of January 1, 2011. The California Building Standards Code is a compilation of three types of building standards from three different origins:

- Building standards that have been adopted by state agencies without change from building standards contained in national model codes;
- Building standards that have been adopted and adapted from the national model code standards to meet California conditions; and
- Building standards, authorized by the California legislature, that constitute extensive additions not covered by the model codes that have been adopted to address particular California concerns.

In the context of earthquake hazards, the California Building Standards Code's design standards have a primary objective of assuring public safety and a secondary goal of minimizing property damage and maintaining function during and following seismic events. The 2010 CBC assigns a seismic design category (SDC) to each structure. The SDC is assigned as a means of capturing both the seismic hazard, in terms of mapped acceleration parameters (spectral values), site class (defining the soil profile), and the occupancy category (based on its importance or hazardous material contents). The SDC affects design and detailing requirements as well as the structural system that may be used and its height.

Project Consistency

The project would be constructed in conformance with the most recent version of the California Building Code to minimize potential impacts of ground shaking. The project therefore would be consistent with the California Building Code.

Alquist-Priolo Earthquake Fault Zoning Act

The California Legislature passed the Alquist-Priolo Earthquake Fault Zoning Act in 1972 to mitigate the hazards of surface faulting. The act's main purpose is to prevent the construction of buildings used for human occupancy on any surface trace of an active fault.

Project Consistency

The project site is not located on any surface trace of an active fault, pursuant to the Alquist-Priolo Earthquake Fault Zoning Act. The project is therefore consistent with this policy.

Seismic Hazard Mapping Act

The Seismic Hazard Mapping Act was passed in 1990 following the Loma Prieta earthquake to reduce threats to public health and safety and to minimize property damage caused by earthquakes. The act directed the California State Geologist to identify and map areas prone to the earthquake hazards of liquefaction, earthquake-induced landslides, and amplified ground shaking. Within the Zones of Required Investigation, the act requires site-specific geotechnical investigations to identify potential seismic hazards and to formulate mitigation measures prior to permitting most developments designed for human occupancy.

Sunnyvale General Plan

The Safety and Noise Element of the Sunnyvale General Plan contains the following relevant policies related to geology and soils:

Policy SN-1.1 Evaluate and consider existing and potential hazards in developing land use policies. Make land use decisions based on an awareness of the hazards and potential hazards for the specific parcel of land.

Policy SN-1.8 Maintain lifelines in good operating condition to lessen damage and increase survivability after a major disaster.

Policy SN-2.1 Construct or maintain city facilities utilized for emergency response to essential services buildings, so that they remain operable after a major seismic event.

To reduce the risk of seismic hazards the City requires the preparation of geotechnical reports for all new developments and actively participates in the State of California Seismic Hazards Mapping Program.

Project Consistency

Hazards and potential hazards related to the project would be analyzed through the preparation of a geotechnical report, and the City actively participates in the State of California Seismic Hazards Mapping Program. Therefore, the project would be consistent with the Sunnyvale General Plan and the Seismic Hazard Mapping Act.

4.5.3 IMPACTS AND MITIGATION MEASURES

Significance Criteria

Appendix G of the CEQA Guidelines identifies environmental issues to be considered when determining whether a project could have significant effects on the environment. As identified in Appendix G, the project would have a significant geology and soils impact if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
ii. Strong seismic ground shaking;
iii. Seismic-related ground failure, including liquefaction; or
iv. Landslides;

- Result in substantial soil erosion or the loss of topsoil;
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on-or off site landslide, lateral spreading, subsidence, liquefaction or collapse;
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property; or
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Discussion of No Impacts

Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault?

The project site is not crossed by an active fault, nor is it located within a designated State of California Earthquake Fault Zone (2010) for active faulting. The project site is located more than eight miles from the San Andreas Fault, which is the nearest Alquist-Priolo earthquake fault to the project site. Therefore, the project would not expose people or structures to potential substantial adverse effects from rupture of a known earthquake fault. No mitigation would be required.

Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving landslides?

The project site and its immediate surroundings are relatively flat and do not contain steep slopes or hillsides that would be susceptible to landslides. Therefore, the project would not expose people or structures to a significant risk of landslides. No mitigation would be required.

Would the project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

The project does not entail the installation or use of any septic tanks or wastewater disposal systems. Therefore, no impact would occur and no mitigation would be required.

Discussion of Less-than-Significant Impacts

Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving seismic-related ground failures, including liquefaction?

The project site is at low risk for seismic-related ground failures. The subsurface investigation performed as part of the Foundation Report for the project did not encounter significant layers of saturated non-cohesive silts or loose clean sands. Isolated pockets of potentially liquefiable sandy soils were found at the project site but do not present significant risk to the soil behaviors at the site given that they are thin and surrounded by non-liquefiable soils. According to the U.S. Geological Survey (2006), the project site is located in an area mapped as having moderate liquefaction susceptibility. Somewhat stronger shaking (PGA > 0.1 to 0.2g) is required to cause liquefaction of deposits mapped with moderate susceptibility. The liquefaction probability for a magnitude 7.8 San Andreas Fault earthquake scenario is between zero and five percent in the project site.[10]

Furthermore, the project is intended to bring the bridge up to current seismic safety standards. Retrofits of bridge abutments, footings, and columns would be beneficial to long-term viability and overall safety, particularly related to seismic activity and potential ground failures.

Due to the type of soils present, the project site has a very low liquefaction hazard. In all, the project's proposed seismic improvements would reduce the risk of exposing people to various seismic-related hazards. Project impacts would thus be less-than-significant and no mitigation would be required.

[10] U.S. Geological Survey. 2008. Liquefaction Hazard Maps, San Andreas Fault M 7.8 Scenario. Available at: http://earthquake.usgs.gov/regional/nca/liquefaction/. Accessed 1/29/14.

Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

The surface soils at the project site consist of dense sand and stiff clay soils with moderate expansion potential. Clay and associated materials can result in weak, compressible, or expansive soils. While soil with moderate expansive soil exists within the project site, the existing bridge foundation is located at a depth that would be unaffected by potentially expansive soil because it is below the surface soil. The proposed foundation infrastructure would be located at a deeper depth than the existing bridge foundation, thus foundation distress owing to expansive soils is not anticipated. The impact would be less than significant and no mitigation would be required.

Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking?

Earthquakes along several nearby active faults in the region could cause strong to very strong ground shaking at the project site due to the project site's location in a seismically active region. The ground shaking intensity at the project site during a major earthquake in the San Francisco Bay Area is estimated at a level VII or VIII on the Modified Mercalli Intensity Scale. (See **Table 4.5-2** for a description of the Modified Mercalli Intensity Scale.) According to the U.S. Geological Survey soil type and shaking hazard map for the San Francisco Bay Area (2012), the project site included some Quaternary muds, sands, gravels, silts, and significant amplification of shaking by these soils is generally expected. The intensity of the earthquake ground motions and the damage done by them would depend on the characteristics of the generating fault, distance to the fault and rupture zone, earthquake magnitude, earthquake duration, and site-specific geologic conditions.

Given that the project does not involve the construction of any new structures and rehabilitates an existing bridge, which will improve its structural integrity, the project would not result in any substantial new seismic ground-shaking risk to people or structures. Project impacts would thus be less-than-significant and no mitigation would be required.

Would the project result in substantial soil erosion or the loss of topsoil?

The project entails some excavation for the installation of new foundations and footing retrofits. Once construction is complete, the potential for soil erosion at the project site would be minimal. Soil erosion during construction is expected to be low due to the lack of slopes and relatively high percentage of existing impervious surface, rendering project impacts to a less-than-significant level. No mitigation would be required.

Would the project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on-or off site landslide, lateral spreading, subsidence, liquefaction or collapse?

Per the Foundation Report, soil conditions underlying the bridge are at very low to minimal risk of landslide and liquefaction. The Foundation Report includes a number of preliminary recommendations to address other soils-related concerns. As is routine for a project of this nature, final design plans will be reviewed by a qualified geotechnical engineer, along with the Foundation Report. As warranted, the geotechnical engineer will incorporate into any project plans further recommendation beyond those identified in the Foundation Report. With adherence to recommendations, project impacts would be less than significant.

Excavation would be required for the installation of new foundations and footing retrofits that could result in unstable subsurface soil conditions. To ensure stability of the foundation and subsurface soils, the following mitigation measures would need to be implemented during construction:

Mitigation Measure GEO-1a: Prior to construction, the City shall ensure that plans for constructing foundations have been reviewed by a qualified geotechnical engineer. Plans shall reflect the following:

Mitigation Measure GEO-1b: To account for subsurface soil variation and uncertainty, the subgrade of new footing foundations should be over-excavated approximately two to three feet and replaced with Class 2 aggregate base (AB). If soft and loose, saturated native soil deposits are encountered, deeper excavation would be required to expose firm native soils. The AB should be compacted to a minimum of 95 percent relative compaction (Caltrans standard). The exposed native soils should not be allowed to dry before placement of aggregate base and concrete.

Mitigation Measure GEO-1c: All grading and compaction operations should be performed in accordance with the project specifications and Section 19, Earthwork, of Caltrans Standard Specifications (2010).

Mitigation Measure GEO-1d: Any fill materials imported to the project site should be non-expansive, relatively granular material having a Plasticity Index (PI) of less than 15 and a minimum Sand Equivalent (SE) of 10. The maximum particle size of fill material should not be greater than 4 inches in largest dimension. It should also be non-corrosive, free of deleterious material and should be reviewed by the Geotechnical Engineer. In addition, it is recommended that the materials within three feet of the proposed pavement subgrade should have a minimum R-value of 15. The on-site soils may be used as engineered fill, provided they meet the above criteria.

Mitigation Measure GEO-1e: Areas to receive fill should be clean of vegetation, shrubs, trees, and their roots greater than 1.5 inches in diameter. If soft or saturated soils are encountered during site grading, deeper excavation may be required to expose firm soils.

The implementation of **Mitigation Measure GEO 1a** through **GEO-1e** would ensure that the risks of the project associated with unstable soils would remain at a less-than-significant level.

4.5.4 REFERENCES

Department of Conservation. 2002. How Earthquakes and Their Effects are Measured, Note 32. Available: http://www.conservation.ca.gov/cgs/information/publications/cgs_notes/note_32/Documents/note_32.pdf.

Parikh Consultants, Inc. 2014. Foundation Report Fair Oaks Avenue Overhead City of Sunnyvale, CA.

United States Geological Survey. Liquefaction Hazard Maps, San Andreas Fault M 7.8 Scenario. 2008. Available: http://earthquake.usgs.gov/regional/nca/liquefaction/. Accessed: 1/29/14.

United States Geological Survey. Soil Type and Shaking Hazard in the San Francisco Bay Area. 2012. Available: http://earthquake.usgs.gov/regional/nca/soiltype/. Accessed: 1/29/14.

United States Geological Survey. Susceptibility Map of the San Francisco Bay Area. 2006. Available: http://geomaps.wr.usgs.gov/sfgeo/liquefaction/susceptibility.html. Accessed: 1/29/14.

Figure 4.5-1 Regional Fault Map

This page intentionally left blank.